R&S®SMW-K551
Generation of Digital "Slow IQ" Signals
User Manual

1176.9564.02 ─ 02

Test & Measurement

User Manual

ROHDE&SCHWARZ

This document describes the following software options:

- R&S®SMW-K551
  1413.9724.xx

This manual describes firmware version FW 3.20.324.xx and later of the R&S®SMW200A.

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The following abbreviations are used throughout this manual: R&S®SMW200A is abbreviated as R&S SMW, R&S®EX-IQ-BOX is abbreviated as R&S EX-IQ-BOX, R&S®DigIConf is abbreviated as R&S DigIConf; the license types 02/03/07/11/13/16/12 are abbreviated as xx.

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1 Preface

1.1 About this Manual

This User Manual provides all the information **specific to the options R&S SMW-K551**. All general instrument functions and settings common to all applications and operating modes are described in the main R&S SMW user manual.

The main focus in this manual is on the provided settings and the tasks required to generate a signal. The following topics are included:

- **Welcome to the Slow IQ option R&S SMW-K551**
  Introduction to and getting familiar with the option
- **About the Slow IQ Signal Generation**
  Background information on basic terms and principles in the context of the signal generation
- **Configuration and Settings**
  A concise description of all functions and settings available to configure signal generation with their corresponding remote control command
- **How To Generate Signals with Reduced Speed for FPGA Tests**
  The basic procedure to perform signal generation tasks and step-by-step instructions for more complex tasks or alternative methods
  As well as detailed examples to guide you through typical signal generation scenarios and allow you to try out the application immediately
- **Remote Control Commands**
  Remote commands required to configure and perform signal generation in a remote environment, sorted by tasks
  (Commands required to set up the instrument or to perform common tasks on the instrument are provided in the main R&S SMW user manual)
  Programming examples demonstrate the use of many commands and can usually be executed directly for test purposes
- **List of remote commands**
  Alphabetical list of all remote commands described in the manual
- **Index**

1.2 Documentation Overview

The user documentation for the R&S SMW consists of the following parts:

- Getting Started printed manual
- Online Help system on the instrument, incl. Tutorials
- Documentation CD-ROM with:
  – Getting Started
  – Online help system (Web Help and `*.chm`) as a standalone help

- User Manuals for base unit and options
- Service manual
- Data sheet and product brochure
- Links to useful sites on the Rohde & Schwarz internet

Online Help

The Online Help is embedded in the software. It offers quick, context-sensitive access to the complete information needed for operation and programming. The online help contains help on operating the R&S SMW and all available options.

Getting Started

The Getting Started is delivered with the instrument in printed form and in PDF format on the documentation CD. It provides the information needed to set up and start working with the instrument. Basic operations and typical signal generation examples are described. Safety information is also included.

This manual is available in several languages. You can download these documents from the Rohde & Schwarz website, on the R&S SMW product page at http://www.rohde-schwarz.com/product/SMW200A.html > Downloads > Manuals.

User Manual

User manuals are provided for the base unit and each additional (software) option.

The User Manual for the base unit is a supplement to the Getting Started manual and provides basic information on operating the R&S SMW in general. In this manual, all instrument functions are described in detail. Furthermore, it provides a complete description of the remote control commands with programming examples. An introduction to remote control is provided, as well as information on maintenance, instrument interfaces and troubleshooting.

In the user manuals for the individual software options, the specific instrument functions of this option are described in detail. For additional information on default settings and parameters, refer to the data sheets. Basic information on operating the R&S SMW is not included in these user manuals.

The user manuals are available in PDF format - in printable form - on the Documentation CD-ROM delivered with the instrument.

All user manuals are also available for download from the Rohde & Schwarz website, on the R&S SMW product page at http://www.rohde-schwarz.com/product/SMW200A.html > Downloads > Manuals.

Service Manual

The service manual is available in PDF format on the CD delivered with the instrument. It describes how to check compliance with rated specifications, instrument function, repair, troubleshooting and fault elimination. It contains all information required for repairing the R&S SMW by replacing modules.

Release Notes

The release notes describe the installation of the firmware, new and modified functions, eliminated problems, and last minute changes to the documentation. The corresponding firmware version is indicated on the title page of the release notes.

The latest versions are available for download from the R&S SMW product page, at http://www.rohde-schwarz.com/product/SMW200A.html > Downloads > Firmware.

Web Help

The web help provides online access to the complete information on operating the R&S SMW and all available options, without downloading. The content of the Web Help corresponds to the user manuals for the latest product version.

The web help is available from the R&S SMW product page, at http://www.rohde-schwarz.com/product/SMW200A.html > Downloads > Web Help.

Tutorials

A set of tutorials is embedded in the software. The tutorials offer guided examples and demonstrations on operating the R&S SMW.

Application Notes

Application notes, application cards, white papers and educational notes are further publications that provide more comprehensive descriptions and background information.

A subset of application notes is provided on the documentation CD-ROM delivered with the instrument.

The latest versions are available for download from the Rohde & Schwarz website, at http://www.rohde-schwarz.com/appnotes.

1.3 Conventions Used in the Documentation

1.3.1 Typographical Conventions

The following text markers are used throughout this documentation:

Convention	Description
"Graphical user interface elements"	All names of graphical user interface elements on the screen, such as dialog boxes, menus, options, buttons, and softkeys are enclosed by quotation marks.
KEYS	Key names are written in capital letters.
`File names, commands, program code`	File names, commands, coding samples and screen output are distinguished by their font.

Convention	Description
Input	Input to be entered by the user is displayed in italics.
Links	Links that you can click are displayed in blue font.
"References"	References to other parts of the documentation are enclosed by quotation marks.

1.3.2 Conventions for Procedure Descriptions

When describing how to operate the instrument, several alternative methods may be available to perform the same task. In this case, the procedure using the touchscreen is described. Any elements that can be activated by touching can also be clicked using an additionally connected mouse. The alternative procedure using the keys on the instrument or the on-screen keyboard is only described if it deviates from the standard operating procedures.

The term "select" may refer to any of the described methods, i.e. using a finger on the touchscreen, a mouse pointer in the display, or a key on the instrument or on a keyboard.

1.3.3 Notes on Screenshots

When describing the functions of the product, we use sample screenshots. These screenshots are meant to illustrate as much as possible of the provided functions and possible interdependencies between parameters. The shown values may not represent realistic test situations.

The screenshots usually show a fully equipped product, that is: with all options installed. Thus, some functions shown in the screenshots may not be available in your particular product configuration.

2 Welcome to the R&S SMW-K551 Option

The R&S SMW-K551 is a software option that allows you to generate digital signals with reduced speed. These kind of signals are commonly known as "Slow IQ" signals.

R&S SMW-K551 key features

- Generation of single stream or multiplexed digital signals with potentially reduced speed (a.k.a. "Slow IQ")
- Generation of digital signals with data rate as required by the DUT and as requested by the processing instrument, e.g. R&S EX-IQ-Box
- Simultaneous output of up to eight digital streams on two digital interfaces

This user manual contains a description of the functionality that the application provides, including remote control operation.

All functions not discussed in this manual are the same as in the base unit and are described in the R&S SMW user manual. The latest version is available for download at the product homepage.

Installation

You can find detailed installation instructions in the delivery of the option or in the R&S SMW Service Manual.

2.1 Accessing the Slow IQ Settings

To open the dialog with the required settings

1. In the task bar R&S SMW, select the "System Configuration > System Configuration".

   A dialog box opens that displays the "Fading/Baseband Configuration" settings.

2. Select "Signal Outputs > Digital Only/Digital Only Multiplexed".

3. Select "Ok".

   The signal generation is not started immediately. To start signal generation with the default settings, select "State > On".

2.2 Scope

Tasks (in manual or remote operation) that are also performed in the base unit in the same way are not described here.

In particular, this includes:

- Managing settings and data lists, i.e. storing and loading settings, creating and accessing data lists, accessing files in a particular directory, etc.
- Information on regular trigger, marker and clock signals as well as filter settings, if appropriate.
- General instrument configuration, such as checking the system configuration, configuring networks and remote operation
- Using the common status registers

For a description of such tasks, see the R&S SMW user manual.

3 About the Slow IQ Signal Generation

Testing of systems that do not support real-time signals requires signals with an artificially reduced speed or the so called "slow I/Q" signals. An example of this kind of system are the FPGA-based hardware emulators.

A typical signal generator generates test signals in real time and with sample rate that is several times grater than the sample rate such system can handle. Hence, you have to adjust several signal settings that are often distributed into different dialog boxes, e.g. to change the sampling rate of the baseband signal, to enable down-sampling of the output signal, to calculate and configure fading delay and Doppler shifts, etc.

In R&S SMW equipped with option R&S SMW-K551, the generation of the "slow IQ" signals is a straightforward solution. This section describes how to use the dedicated functions to generate and output "slow IQ" digital signals with a sampling rate as required by the device under test (DUT) and upon a request form a connected R&S®EX-IQ-BOX.

3.1 Required Options and Additional Equipment

In the following, we assume that the R&S EX-IQ-Box device interface module is connected to the R&S SMW. The inter-operation with other devices is not described.

The requirement and the limitations listed in Limitations and Interdependencies with Other Parameters apply to any connected further processing device, that supports the slow I/Q mode.

Required options

The equipment layout for output of digital I/Q signal includes:

- option Baseband Generator (R&S SMW-B10) per signal path and
  option Baseband main module, with two I/Q paths (R&S SMW-B13T)
- two options Digital Baseband Output (R&S SMW-K18)
- four options Fading simulator (R&S SMW-B14)
  (incl. one digital interface FADER 3/4(1/2) per installed option)
  See also chapter 3.3, "Transmission Modes", on page 13.
- option MIMO Fading (R&S SMW-K74)
- option Slow IQ (R&S SMW-K551)
- optional option Multiple Entitities (R&S SMW-K76)
- further options may be required

For more information, refer to the instrument specification (data sheet).

Required additional equipment

One digital interface module **R&S EX-IQ-Box** per digital I/Q interface, each fulfilling the following requirements:

- must have serial number grater than 102000 to support a 200 MHz digital input signal
- should be controlled by the R&S DigIConf software (Digital Interface Configuration for the R&S EX-IQ-Box), to be installed on an external PC
- should be equipped with a single ended or a differential Breakout Board
  For more information, see the R&S EX-IQ-Box Operating Manual

Required cables

- Per digital interface module R&S EX-IQ-Box:
  – one R&S®SMU-Z6 cable for connecting Rohde & Schwarz digital baseband interfaces (i.e. to connect the R&S EX-IQ-Box to the DIG IQ interfaces of the R&S SMW)
  – USB cable for connecting the external PC to the R&S EX-IQ-Box
  – suitable cable for connecting the breakout board of the R&S EX-IQ-Box to the DUT
- LAN cable for connecting the external PC and the R&S SMW to the LAN
- (optional) BNC cable, if a trigger signal is required
- if the test setup requires an external reference frequency is required, additional BNC cables, whereas one of them shorter than 1m and one T adapter
  (see chapter 3.5, "Synchronization Issues", on page 18)

3.2 The Principle of Generation of Signals with Reduced Speed

In the general case, R&S SMW generates the digital streams according to the selected "System Configuration" and maps them to the available analog RF and I/Q outputs *and* to the digital I/Q interfaces. The generated signal may use the maximum supported data rate (see data sheet). When you connect a further processing instrument to the digital interfaces of the R&S SMW, you define the sample rate of the generated signal.

Dedicated modes for the generation of digital signals

R&S SMW equipped with the option Slow IQ (R&S SMW-K551) provides two additional signal outputs modes, the "Digital Only/Digital Only Multiplexed" modes, dedicated for the generation of digital signals. In these modes, the R&S SMW does not output the digital signals continuously but upon a request from a connected further processing device, usually a R&S EX-IQ-Box. The analog RF and I/Q outputs are disabled.

Depending on the further processing device, the R&S SMW may use a reduced data rate.

See also chapter 3.3, "Transmission Modes", on page 13.

Simplified test setup for testing "slow IQ" signals

The figure 3-1 shows an example of a simple test setup for SISO tests.

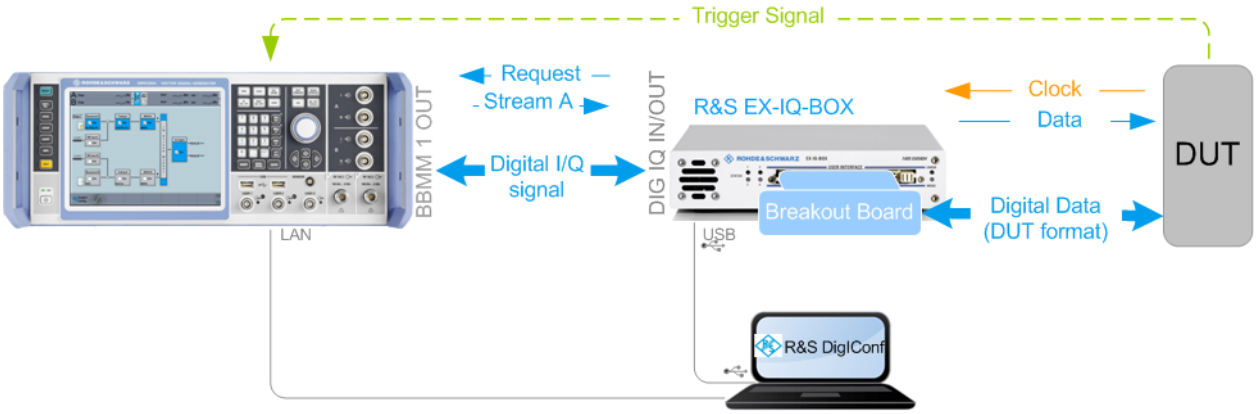


Fig. 3-1: Simplified test setup for SISO tests with "slow IQ" signals

DUT = device under test, e.g. a FPGA-based hardware emulator

The R&S SMW in this setup generates a real time signal according to one of the digital standards, e.g. an EUTRA/LTE. The digital signal is routed to and output at the digital interface BBMM 1 OUT. The R&S EX-IQ-Box serves as a digital baseband interface between a device under test (DUT) and the R&S SMW.

The R&S EX-IQ-Box works as transmitter; it receives the digital I/Q signal from the R&S SMW but also the clock signal of the connected device under test (DUT). The R&S EX-IQ-Box processes the digital signal and outputs it at the user interface (UI) module with the required clock rate. Because this clock rate is lower than the sample rate of the received data, the R&S EX-IQ-Box buffers data samples and monitors its buffer level. At a predefined buffer level, the R&S EX-IQ-Box requests new signal samples form the R&S SMW. Upon this request, the instrument generates the exact amount of samples and with the sample rate of the current digital signal.

The digital signal at the user interface of the R&S EX-IQ-Box carries information in form of data words, where a data word consists of up to 18 data bits (D0..D17). Both the parallel and serial data formats are supported. The digital data is transmitted with a clock rate, as received from the DUT.

Refer to the R&S EX-IQ-Box Operating Manual for detailed information as well as for a description of the pin assignment on the user interface (UI).

3.3 Transmission Modes

The R&S SMW can output the generated digital I/Q signals in two transmission modes, as single steam or as multiplexed signals, see table 3-1.

Table 3-1: Overview of the main differences between the transmission modes

Transmission mode	GUI Setting	Number of digital streams	Suitable for	See also
Single stream	"Signal Outputs > Digital Only"	≤ 4	generating signals with max available bandwidth	"Single stream transmission" on page 14
Multiplexed signals	"Signal Outputs > Digital Only Mux"	≥ 2	with 2xR&S EX-IQ-Box, simultaneous testing of up to 8 streams	"Multiplexed stream transmission" on page 14

The selected transmission mode and system configuration determine the stream mapping of the digital signals to the output digital I/Q interfaces. If multiplexed signals are used, this mapping is fixed (see chapter 3.4, "Default Stream Mapping", on page 16).

Single stream transmission

The generated digital streams are output at the digital I/Q interface, transmitted to the R&S EX-IQ-Box and output at its user interface with the required clock rate.

Multiplexed stream transmission

If multiplexing is used, the R&S SMW outputs up to four multiplexed streams at one digital I/Q interface (BBMM 1/2 OUT); see figure 3-2.

The multiplexing follows the rules:

- streams are numbered as stream#0 to stream#3 per digital I/Q output interface, i.e. stream A at the BBMM 1 OUT and stream B at the BBMM 2 OUT are both indicated as stream#0
- samples belonging to a stream are indicated by a combination of two marker signals UI_GP_0 and UI_GP_4;
  (on figure 3-2 data samples are indicated as $D_{stream\#}$Sample#)
- samples order may vary, see the third sample on figure 3-2
- signal valid (UI_VALID) indicates valid samples, see figure 3-3
- clock signal D_CLK_UIN is required as a reference for PLL
- digital I/Q data is output as I and Q signals UI_I_0 ... UI_I_17 and UI_Q_0 ... UI_Q_17.
- multiplexed samples have to be evaluated one by one (see also figure 3-3)

Example: Signal at the user interface of the R&S EX-IQ-Box (four multiplexed streams)

In the following, we assume:

- an 1xMx8 system configuration, where the four streams B, D, F and H are multiplexed for the BBMM 2 OUT digital interface
- a 16 bit data word and a parallel data format

The figure 3-2 shows the multiplexed signal at the user interface of the R&S EX-IQ-Box.

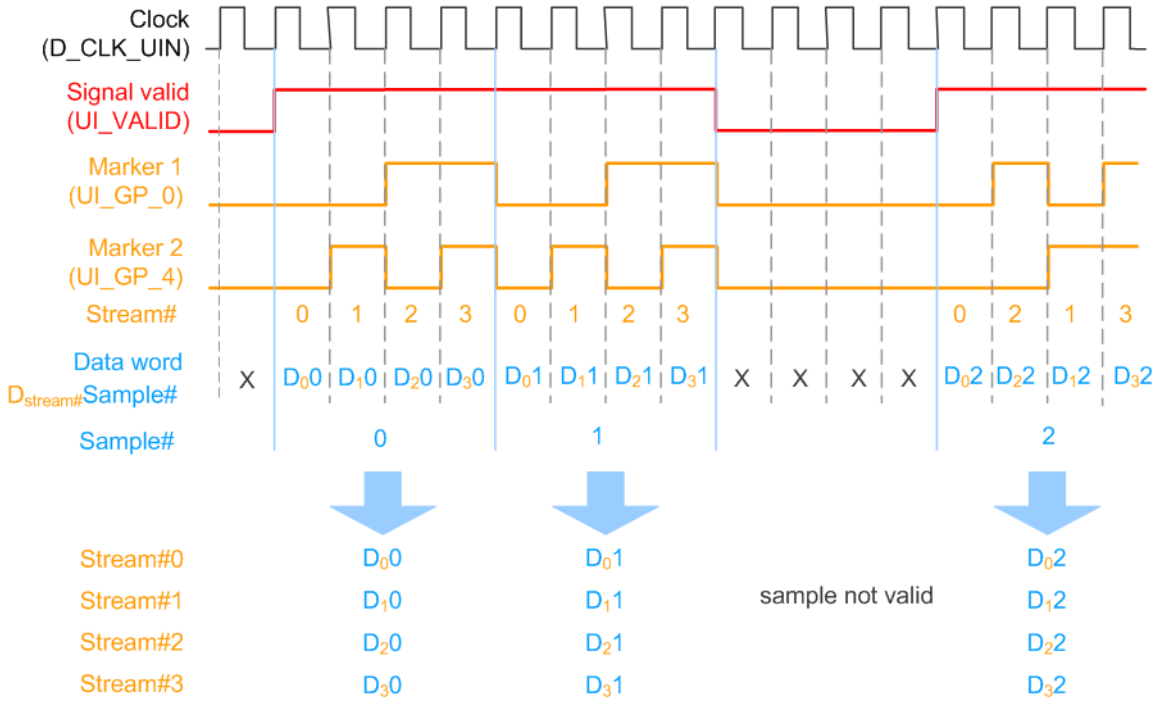

Clock
(D_CLK_UIN)
Signal valid
(UI_VALID)
Marker 1
(UI_GP_0)
Marker 2
(UI_GP_4)
Stream#
Data word
Dstream#Sample#
Sample#
0 1 2 3 0 1 2 3 0 2 1 3
X D0 0 D1 0 D2 0 D3 0 D0 1 D1 1 D2 1 D3 1 X X X X D0 2 D2 2 D1 2 D3 2
0
1
2
Stream#0 D0 0 D0 1 D0 2
Stream#1 D1 0 D1 1 D1 2
Stream#2 D2 0 D2 1 D2 2
Stream#3 D3 0 D3 1 D3 2
sample not valid

Fig. 3-2: Example: Signal at the user interface of the R&S EX-IQ-Box (four multiplexed streams)

Stream#0 = Stream B
Stream#1 = Stream D
Stream#2 = Stream F
Stream#3 = Stream H

Example: Signal at the user interface of the R&S EX-IQ-Box (one multiplexed stream)

In the following, we assume:

- an 1xMx3 system configuration, where the stream B is multiplexed for the BBMM 2 OUT digital interface
- there is no second stream multiplexed on this digital interface
- the samples of stream B are indicated as Stream#0; all other samples are unused and should be discarded

The figure 3-3 shows the multiplexed signal at the user interface of the R&S EX-IQ-Box.

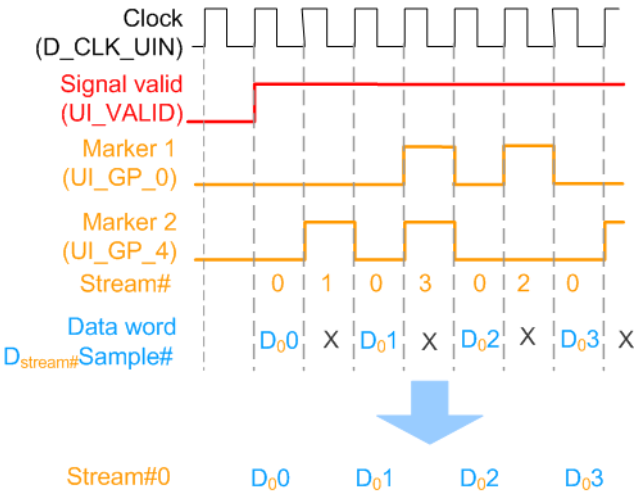


Fig. 3-3: Example: Signal at the user interface of the R&S EX-IQ-Box (one multiplexed stream)

X = unused samples (to be discarded)
Stream#0 = Stream B

3.4 Default Stream Mapping

The table 3-2 and table 3-3 provide information on the default stream mapping to the digital interfaces, default interface direction and possible configurations depending on the selected system configuration and the transmission mode (single or multiplexed streams).

See chapter 3.1, "Required Options and Additional Equipment", on page 11 for an overview of the required options for each transmission type.

The following abbreviations are used:

- * depicts two or more multiplexed streams
- M depicts the number of generated basebands; value range 1 .. 8

Table 3-2: Single stream ("Signal Outputs > Digital Only"): Possible scenarios and default stream mapping

System Configuration	BBMM 1 OUT	BBMM 2 OUT	FAD 3 OUT	FAD 4 OUT
1xMx2	Stream A	Stream B	-	-
1xMx3	Stream A	Stream B	Stream C	-
1xMx4 2xMx2	Stream A	Stream B	Stream C	Stream D

Table 3-3: Multiplexed streams ("Signal Outputs > Digital Only Multiplexed"): Possible scenarios and default stream mapping

System Configuration	BBMM 1 OUT	BBMM 2 OUT
1xMx2	n.a	n.a
1xMx3	Stream A*C	Stream B

System Configuration	BBMM 1 OUT	BBMM 2 OUT
1xMx4 2xMx2	Stream A*C	Stream B*D
1xMx8 3xMx2 4xMx2 5x1x1	Stream A*C*E*G	Stream B*D*F*H

3.4.1 Limitations and Interdependencies with Other Parameters

When you generate digital signals (I/Q streams) as "slow IQ" signals, consider that the following applies:

- the R&S SMW synchronizes the generated baseband to its internal clock signal; external clock signals are not supported.
- the clock rate required by the R&S EX-IQ-Box should not exceed the sampling rate of the generated digital signal:
  $ClockRate_{R\&S\ EX\text{-}IQ\text{-}Box} \leq SamplingRate_{Stream}$*#MuxStreams
  (see also example "How to find out the max $ClockRate_{R\&S\ EX\text{-}IQ\text{-}Box}$ for that an additional reference frequency is not required" on page 18.)
- if multiplexed streams are used, the generated baseband signals have limited maximum baseband bandwidths $BW_{Baseband\_max}$, which also influence the baseband bandwidth related parameters, like for example the maximum frequency offset, ARB sample rate, AWGN, etc.
  See table 3-4.
  Note: The maximum stream bandwidth must not exceed the provided maximum baseband bandwidth: $BW_{Stream} \leq BW_{Baseband\_max}$

Table 3-4: Multiplexed streams ("Signal Outputs > Digital Only Multiplexed"): Maximum baseband bandwidth depending on the number of multiplexed streams

#MuxStreams	Baseband bandwidth related parameters, e.g. frequency offset	$BW_{Baseband\_max}$
1, 2	+/- 200 MHz	80 MHz
3, 4	+/- 100 MHz	80 MHz
> 4	+/- 50 MHz	40 MHz

To utilize the full available stream bandwidth BW_{Stream}, use the single stream transmission.

Consider that one R&S EX-IQ-Box per streams is required.

3.5 Synchronization Issues

In test setups with more than one instruments, it is essential that all instruments use the same reference clock.

While testing DUTs with "slow IQ" signals, the clock signal is usually provided by the DUT. Even in a test setup with more than one R&S EX-IQ-Box, you only have to distribute the clock signal of the DUT to the R&S EX-IQ-Box and to set the clock rate to the required value. Additional reference frequency is not required. See also figure 5-1.

If you, however, generate signals with clock rate that is equal to the sampling rate of the digital standard, you have to provide all instruments with the same reference frequency (see figure 3-4).

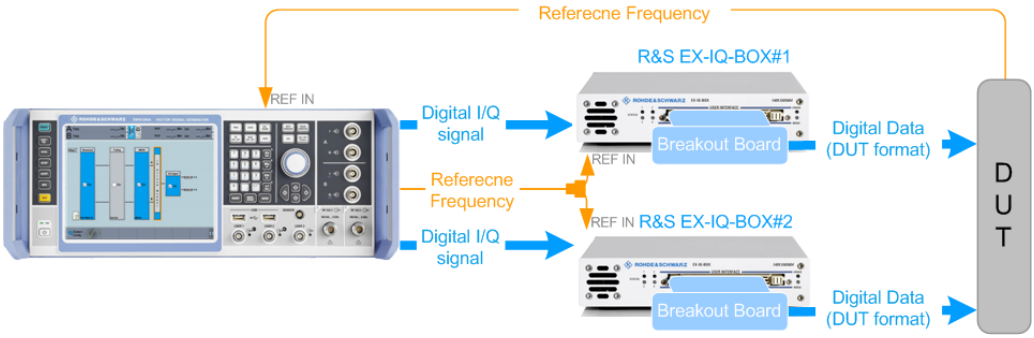


Fig. 3-4: Simplified test setup for MIMO tests with external reference signal

* = not all required connections are shown

Example: How to find out the max $ClockRate_{R\&S\ EX\text{-}IQ\text{-}Box}$ for that an additional reference frequency is not required

The clock rate of the R&S EX-IQ-Box is calculated by the formula:

$ClockRate_{R\&S\ EX\text{-}IQ\text{-}Box} < SamplingRate_{Stream}$*#MuxStreams

- Assume that the R&S SMW generates one digital stream with $SamplingRate_{Stream}$ = 100 MHz.
  If the DUT requires a signal with Clock Rate < 100 MHz, no additional reference frequency is required.
- If the R&S SMW generates *two* streams with $SamplingRate_{Stream}$ = 100 MHz each, an additional reference frequency is required for Clock Rate = 200 MHz.

4 Slow IQ Related Settings

Generation of slow IQ signals is a feature that requires the additional option R&S SMW-K551.

To access the "System Configuration" settings

1. In the task bar R&S SMW, select the "System Configuration > System Configuration".

   The "Fading/Baseband Configuration" settings are displayed.

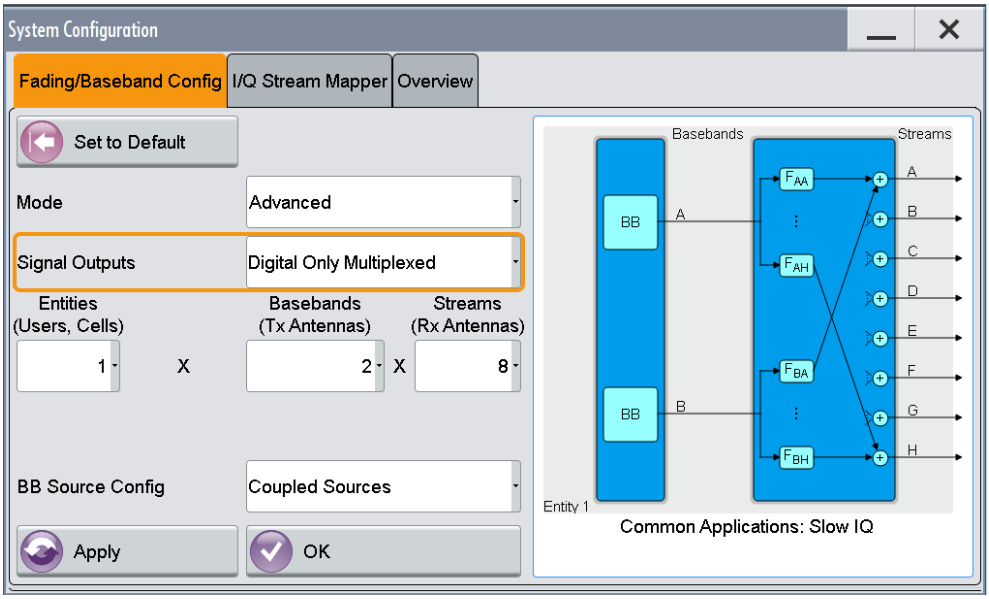
2. Select "Signal Outputs > Digital Only Multiplexed".

3. Configure for example an 1x2x8 MIMO scenario:

   a) Select "Mode > Advanced"
   b) Select "Entities = 1", "Basebands = 2" and "Streams = 8"
   c) Select "BB Source Config > Coupled Sources"

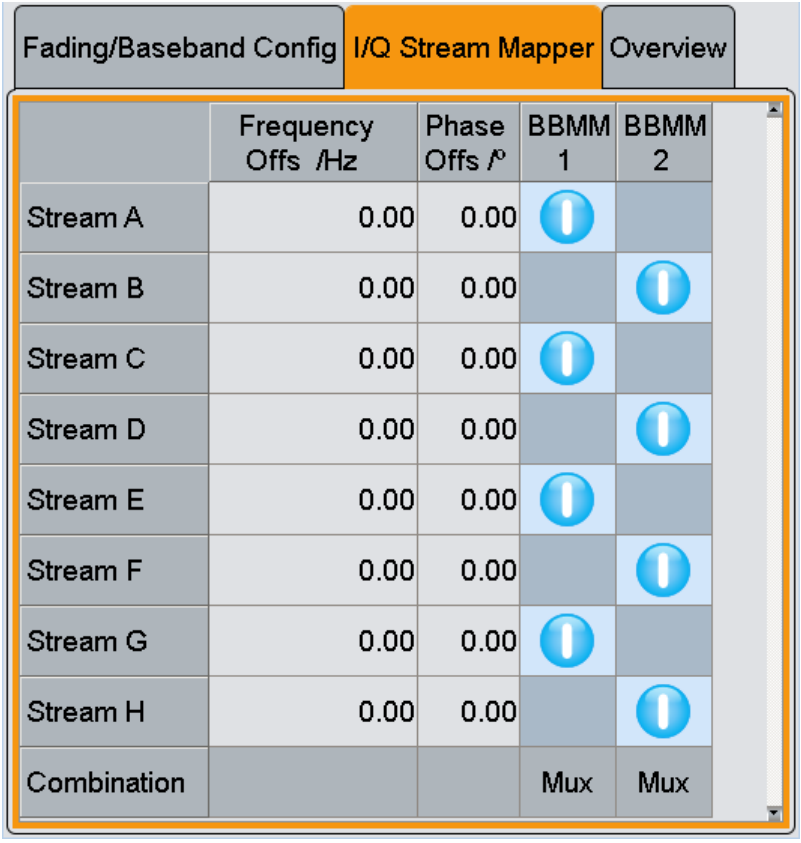
4. Select "Apply".

   With the selected configuration the instrument generates digital signals only; the analog outputs are disabled and the "External RF and IQ" tab is not displayed.

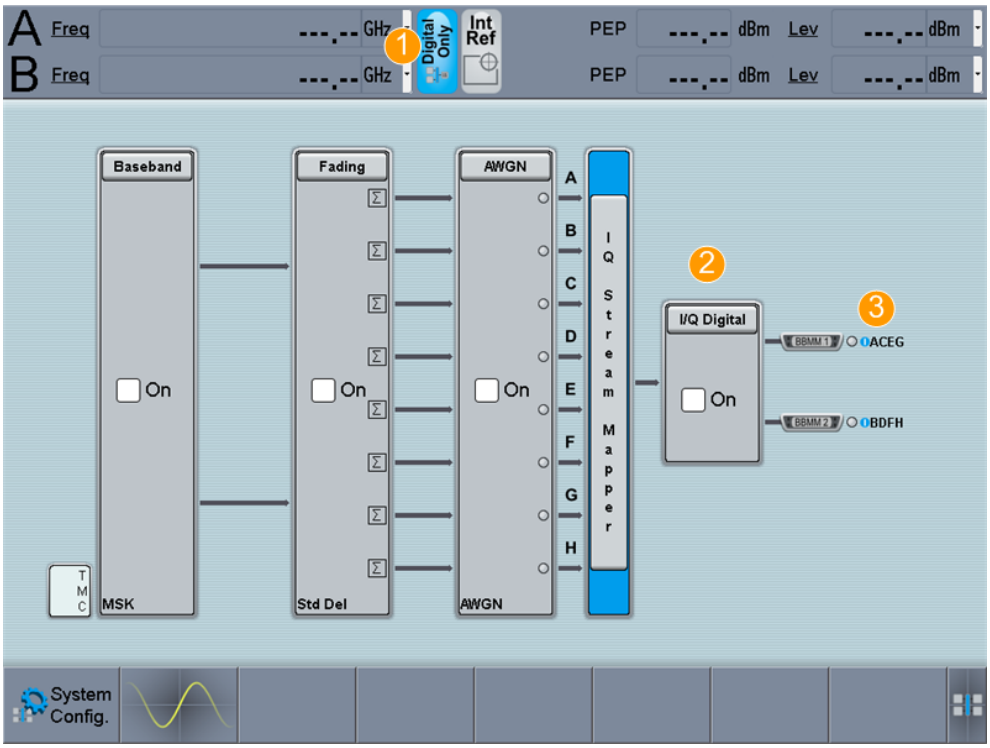


5. Select "I/Q Stream Mapper" to observe the mapping of the generated streams to the digital I/Q interfaces.

   The generated digital streams are mapped to the digital interfaces, as described in Default Stream Mapping; if multiplexed streams are used, the mapping is fixed.



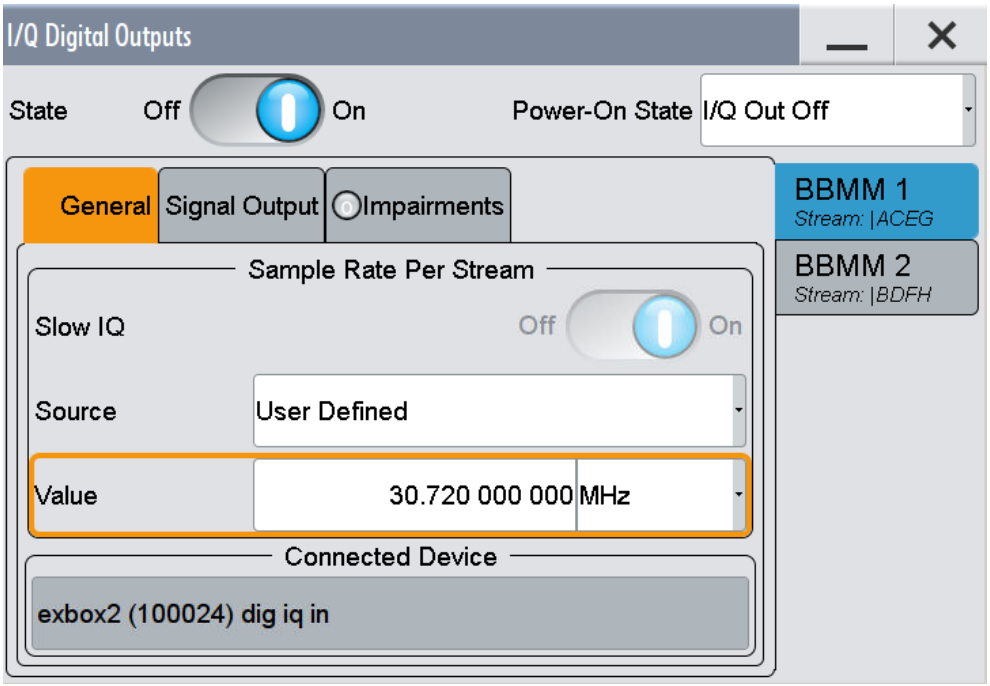
The block diagram confirms the generation of digital only signals, too.



1 = status indication confirming the generation of digital signals; all other indication on task bar are disabled
2 = disabled analog RF and I/Q outputs
3 = indication of multiplexed streams, e.g. streams A*C*G*E are routed to the BBMM 1 connector (see table 3-3)

To access the "I/Q Digital" settings

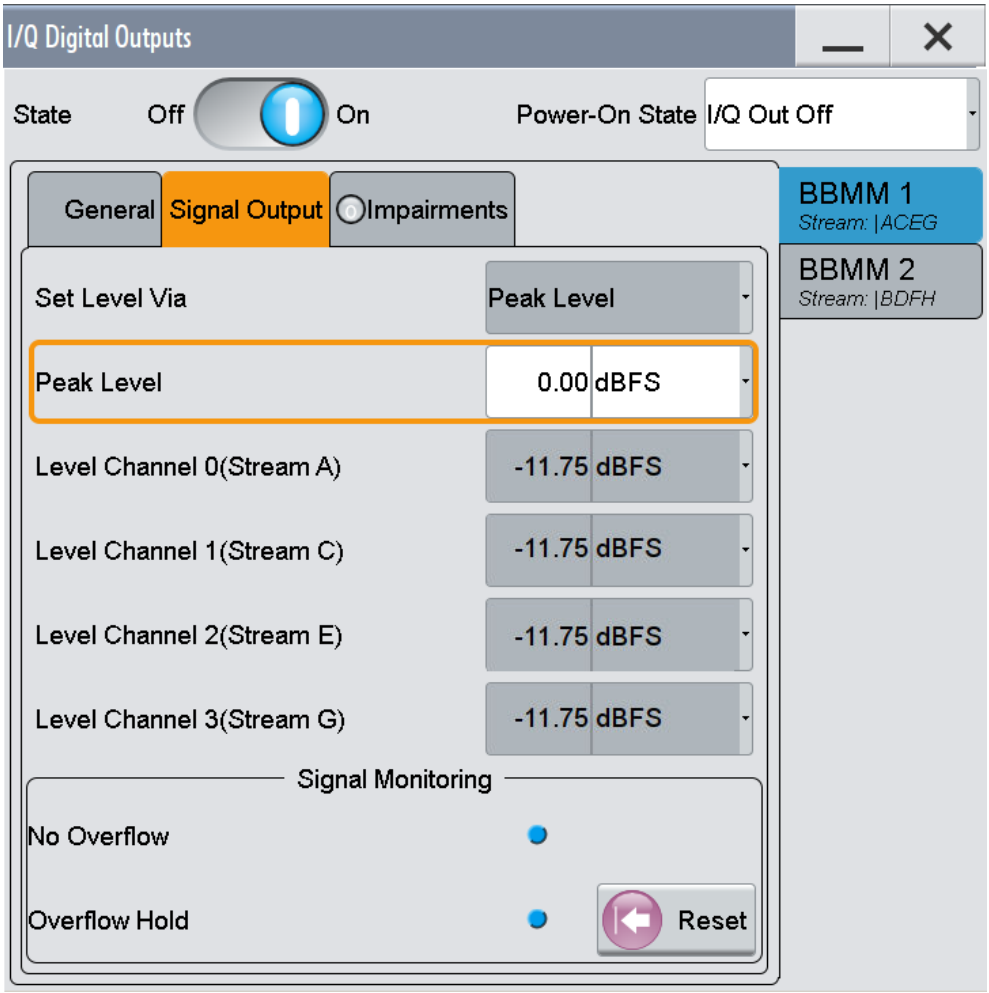
1. In the block diagram, select "I/Q Digital".



Note:
Multiplexed digital streams that are routed to the same digital output interface BBMM 1 or BBMM 2 have the same signal parameters:

- sampling rate, i.e. the available bandwidth is distributed evenly
- impairments
- parameters describing the digital output signal, i.e. peak level and level values.

2. To configure the level settings of the output streams, select "Signal Output".



For step-by-step description on how to use the provided settings, refer to chapter 5, "How To Generate Signals with Reduced Speed for FPGA Tests", on page 24.

System Configuration> Fading/Baseband Configuration
Available are the standard settings and the following parameter, dedicated to the "slow IQ" signal generation.

Signal Outputs ← System Configuration> Fading/Baseband Configuration
Defines whether an analog and digital or digital only signal is generated.

"Analog&Digital"
In this default mode, the instrument generates signals with high data rate.
Generated streams can be mapped to the analog connectors (RF/I/Q OUT) and to the digital I/Q interfaces (BBMM/FAD).

"Digital Only/Digital Only Multiplexed"

(requires option R&S SMW-K551)
R&S SMW can generate digital signals with reduced speed, depending on the device connected to the digital I/Q interfaces.

The supported configuration and mapping of the generated streams to the digital I/Q interfaces depends on the selected mode:

- In "Digital Only" mode, up to 4 streams can be mapped to the digital I/Q interfaces.
- In "Digital Only Multiplexed" mode, the multiplexed streams are mapped to the digital I/Q interfaces BBMM 1/2; the mapping is fixed.

See user manual R&S®SMW-K551 Generation of Digital "Slow IQ" Signals.

Remote command:
`:SCONfiguration:OUTPut:MODE` on page 29

I/Q Digital Outputs
Available are the standard settings and the following parameters, dedicated to the "slow IQ" signal generation.

Slow IQ State ← I/Q Digital Outputs
If "Digital Only" or "Digital Only Multiplexed" signals are generated, this parameter shows whether a "Sample Clock Request" is enabled in the connected R&S EX-IQ-Box.

All digital outputs must work in tha same mode, i.e. with "Slow IQ = On" or "Slow IQ = Off". A warning symbol indicates a violation of this rule.

Level Channel# (Stream) ← I/Q Digital Outputs
Displays the resulting signal level of each multiplexed stream.

5 How To Generate Signals with Reduced Speed for FPGA Tests

The following is a list of some important settings. Not all required settings are considered.

For detailed information on the required steps, refer to the documents listed in chapter 7, "Further Information", on page 30.

How To Generate a 1x2x4 MIMO Digital Signal for FPGA Tests with Slow IQ Signals

The test setup and the configuration required to generate signals with reduced speed undergoes a group of main steps. The explanation of the configuration principle is based on one particular use case.

1. Connecting the instruments.
   See "To connect the instruments for "slow IQ" tests" on page 24
2. Configuring the R&S SMW to generate the required signal.
   See "To configure the R&S SMW" on page 24
3. Configuring the DUT (if required) and determining its clock rate.
4. Configuring the digital interface module R&S EX-IQ-Box.
   See "To configure the R&S EX-IQ-Box" on page 25

To connect the instruments for "slow IQ" tests

Use the example test setup on figure 3-1 but use four R&S EX-IQ-Box instead.

The test setup assumes a $ClockRate_{R\&S\ EX\text{-}IQ\text{-}Box} < SamplingRate_{Stream}$.

1. Connect the four interface modules R&S EX-IQ-Box to the R&S SMW.
   Connect the DUT to the four interface modules R&S EX-IQ-Box.
2. Provide all four interface modules R&S EX-IQ-Box with the clock signal of the DUT to ensure a synchronous signal generation.

To configure the R&S SMW

1. Select "System Configuration" and:
   a) enable a 1x2x4 MIMO scenario
   b) enable "BB Sources > Coupled"
   c) select "Signal Outputs > Digital Only".
2. Enable the generation of a baseband signal, e.g. :
   a) select "Baseband > EUTRA/LTE" and enable a signal with "Channel Bandwidth = 20 MHz", e.g. select "General > Test Models > E-TM1_1__20MHz"

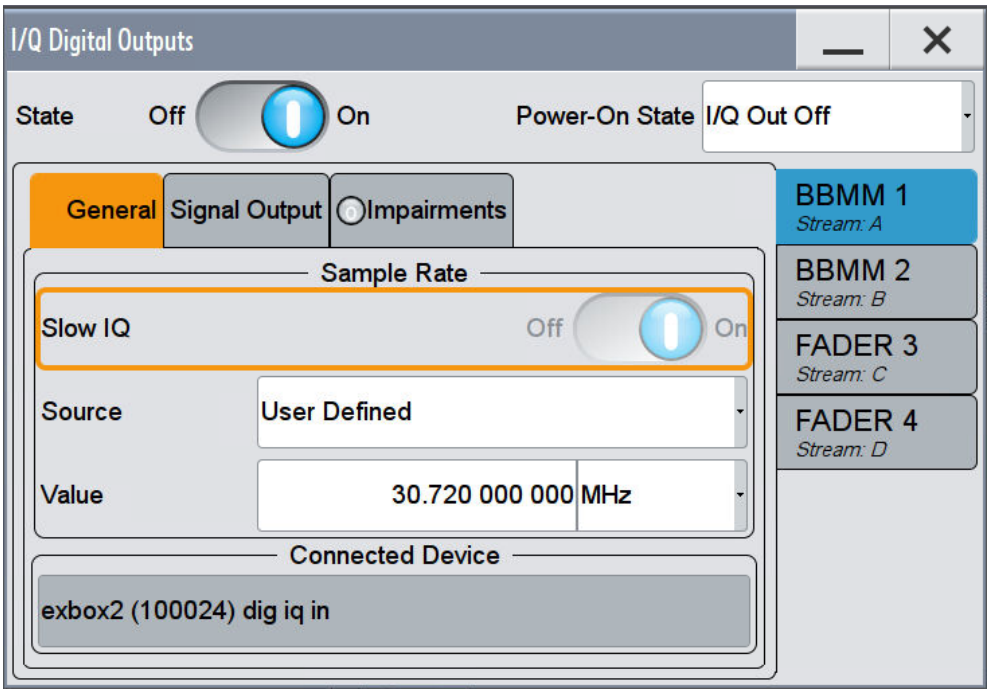
b) Select "EUTRA/LTE > General > Filter/Clipping ... > Filter".
The parameter "Sample Rate Variation = 30.72 MHz" indicates the user sample rate.
c) Select "EUTRA/LTE > State > On".

3. Select "I/Q Digital Outputs > General" and for each of the streams configure:

a) "Source > User Defined"
b) "Value = 30.72 MHz"

Each generated stream will be generate with this sample rate.

4. Select "I/Q Digital Outputs > State > On"

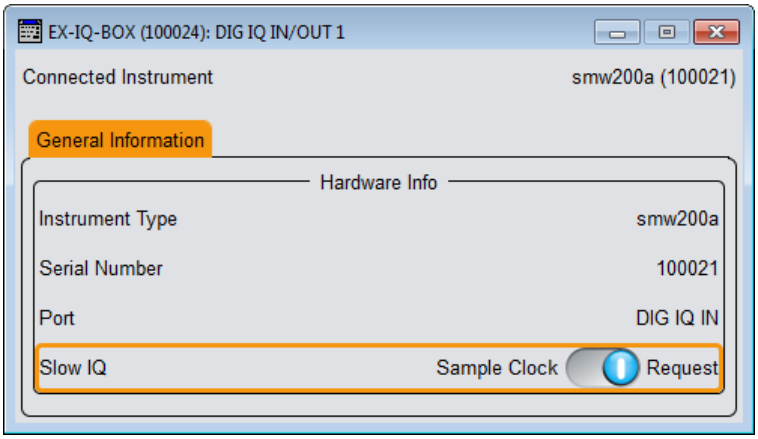


To configure the R&S EX-IQ-Box

We assume that an external PC is connected to the R&S EX-IQ-Box, the R&S DigIConf software is running on this external PC and the R&S EX-IQ-Box is controlled form the software.

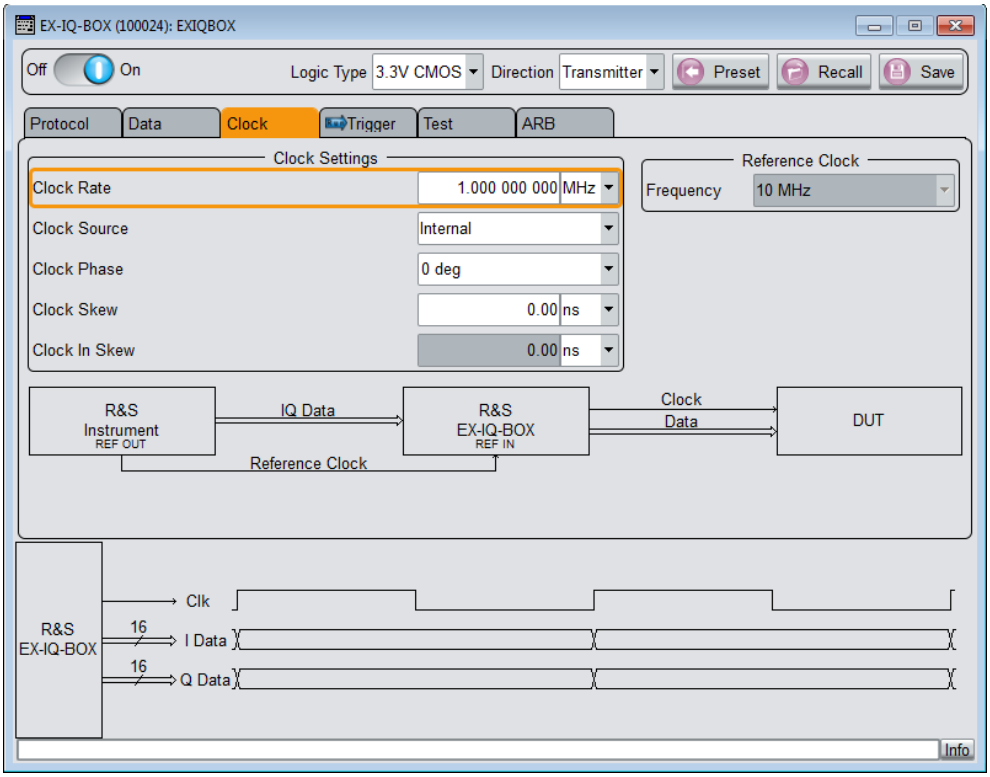
Several settings of the R&S EX-IQ-Box have to be configured are required by the connected DUT.

1. Start the R&S DigIConf software.
2. Select "DIG-IQ-IN > SMW > Hardware Info > Slow I/Q Sample Clock Request > On".

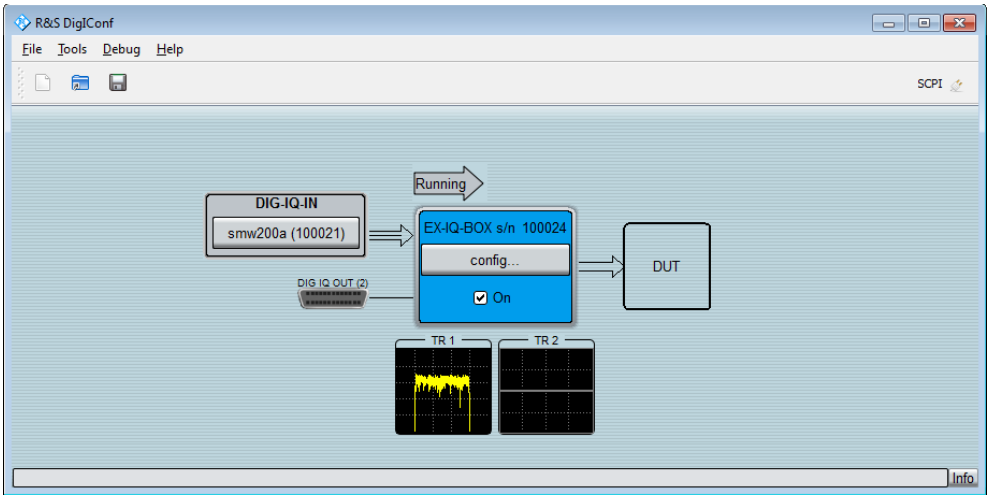


In the R&S SMW, the parameter "I/Q Digital Outputs > General > Slow IQ > State > On" confirms that the R&S EX-IQ-Box requests the sample clock automatically.

3. Select "EX-IQ-Box: User Defined > Direction > Transmitter".
4. Select "EX-IQ-Box: User Defined > Protocol" and "EX-IQ-Box: User Defined > Data" and change the default settings, if required.
5. Select "EX-IQ-Box: User Defined > Clock" and configure:
   - "Clock Source > User Interface"
   - set the value of the parameter "Clock Rate" to the clock required by the DUT, i.e. $ClockRate_{EX\text{-}IQ\text{-}Box} = Clock_{DUT}$.
     E.g. if the DUT requires a 1 MHz clock signal, $ClockRate_{EX\text{-}IQ\text{-}Box}$ = 1 MHz

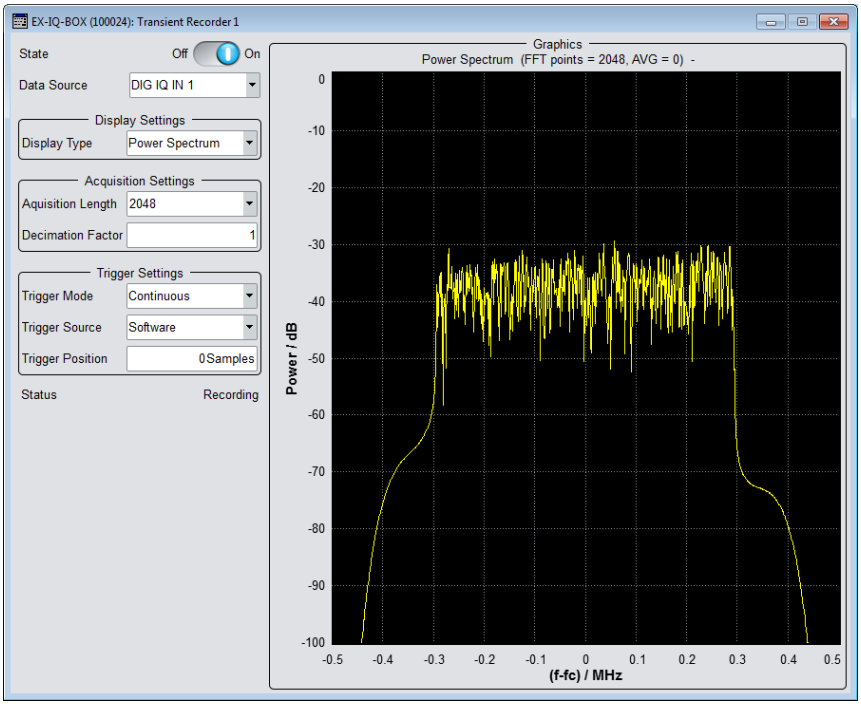


6. Select "EX-IQ-Box: User Defined > State > On".



7. In the R&S DigIConf, select the smart graphic "TR1" to enlarge it.

   The "Transient Recorder" dialog opens and confirms the expected LTE spectrum.



How To Generate a 1x2x8 MIMO Digital Signal for FPGA Tests with Slow IQ Signals

Follow the main steps described in "How To Generate a 1x2x4 MIMO Digital Signal for FPGA Tests with Slow IQ Signals" on page 24:

1. Connecting the instruments as shown on figure 5-1.

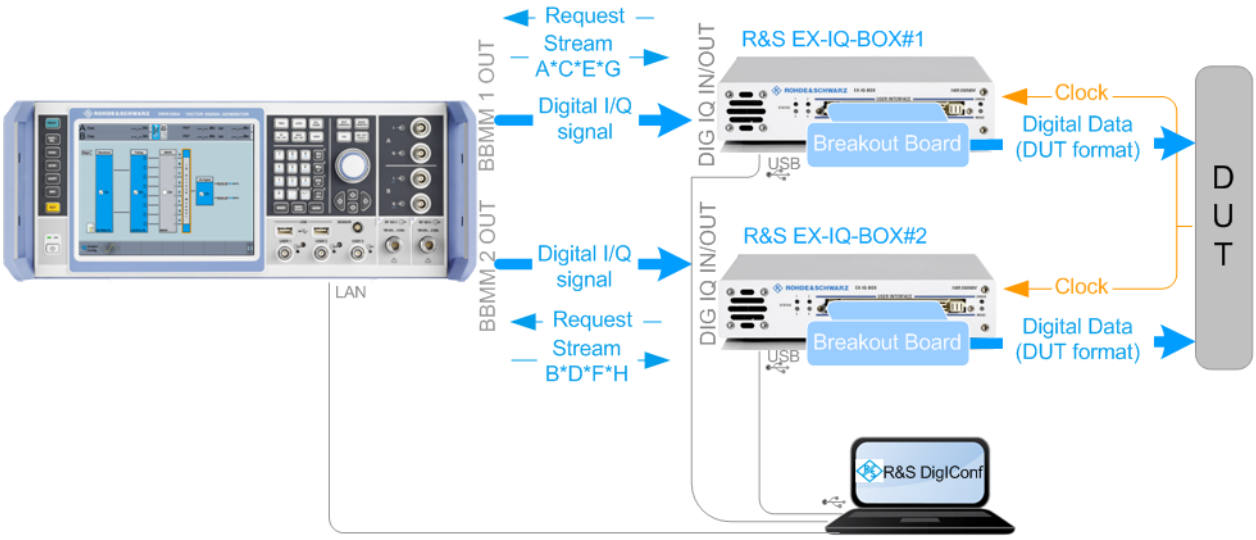


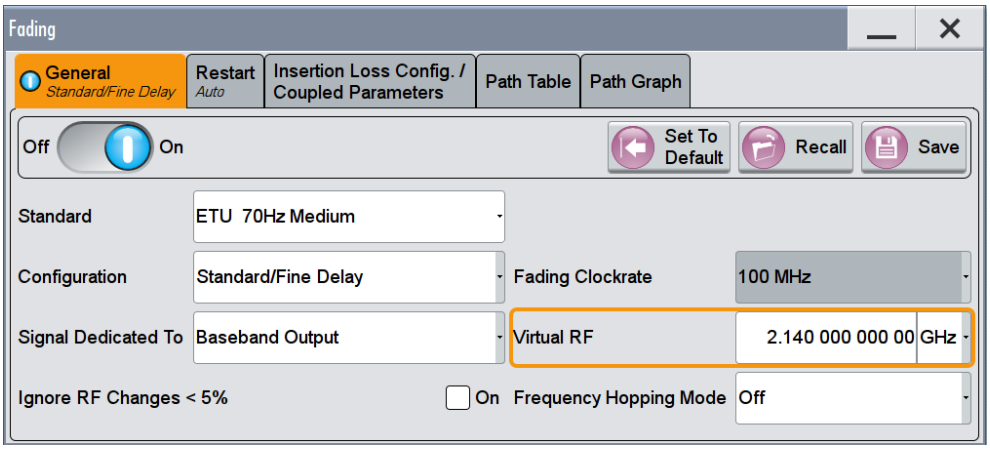
Fig. 5-1: Simplified test setup for 2x8 MIMO tests with "slow IQ" signals

Clock = the clock signal of the DUT must be provided to both R&S EX-IQ-Box

2. Configure the R&S SMW to generate the required signal.
   For example, an LTE signal in a 1x2x8 MIMO configuration and enable "Signal Outputs > Digital Only Multiplexed".

3. If Fading simulation is required:

   a) select "Fading > General > Virtual RF = 2.14 GHz"
   b) select "Fading > Standard > LTE-MIMO > ETU 70Hz Medium"
   c) select "Fading > State > On"



4. Configure the DUT (if required) and sets its clock rate.

5. Configure the digital interface module R&S EX-IQ-Box as described in "To configure the R&S EX-IQ-Box" on page 25.

   The generated signal is processed in a way, that each of the four multiplexed stream will have a sampling rate of 250 KHz.

6 Remote Control Commands

:SCONfiguration:OUTPut:MODE <Mode>

Defines whether an analog and digital or digital only/digital multiplexed signal is generated.

Parameters:

<Mode> DIGMux | DIGital | ALL

ALL
The generated signal is output at the analog and the digital interfaces

DIGital | DIGMux
The generated signal is output as single stream or multiplexed digital signal at the digital interfaces

*RST: ALL

Example: `SCONfiguration:OUTPut:MODE DIGMux`

Options: DIGMux|DIGital require option R&S SMW-K551

Manual operation: See "Signal Outputs" on page 22

7 Further Information

For a comprehensive description of the R&S SMW, R&S EX-IQ-Box and R&S DigIConf software, refer to:

- the R&S SMW user manual
- the R&S EX-IQ-Box - Digital Interface Module & DigIConf Configuration Software Operating Manual
- the EUTRA/LTE Digital Standard for R&S SMW user manual

The latest versions are available for download at the product homepage

- http://www.rohde-schwarz.com/product/SMW200A.html
- http://www.rohde-schwarz.com/product/EX-IQ-Box.html

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